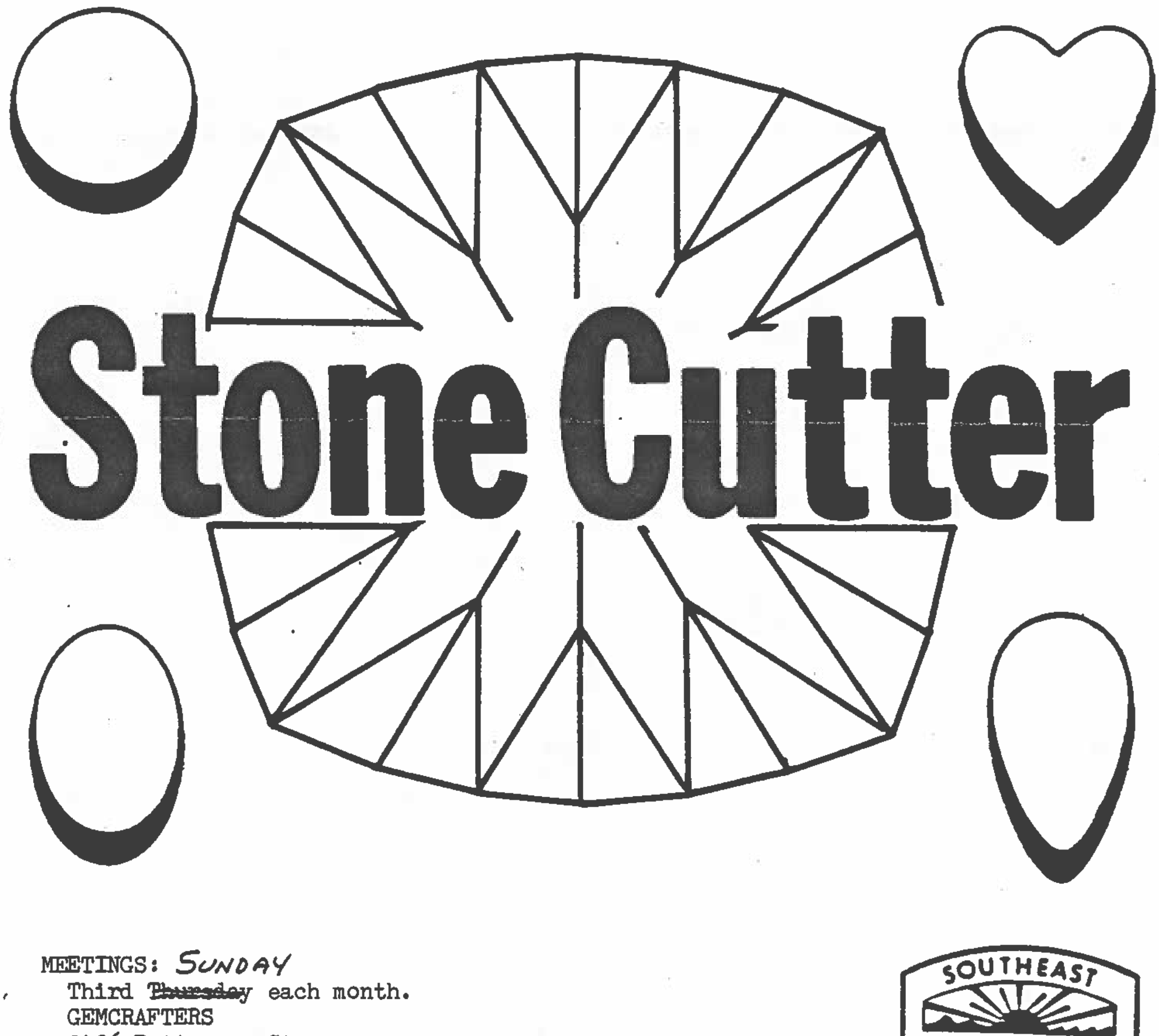
NORTH CAROLINA LAPIDARY SOCIETY

November 1982

Stone Cutter



MEETINGS: SUNDAY
Third ~~Thursday~~ each month.
GEMCRAFTERS
2106 Patterson St.
Greensboro, NC 27407

SOUTHEAST FEDERATION MINERALOGICAL SOCIETIES, INC.

MEETING DATE : November 21, 1982

TIME : 2:30 PM

PLACE : GEMCRAFTERS
2106 Patterson St.
Greensboro, NC

PROGRAM : This meeting will be entirely given over to setting-up our club case of members' work for exhibit at the Greensboro Gem and Mineral Club show in December.

Your stones, carvings, jewelry -whatever- are needed to make the case truly representative of all members' interests.

OFFICERS 1982

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EXECUTIVE BOARD meets at the call of the president.

MEMBERSHIP DUES : $12.00 per year - prorated quarterly.

STONE CUTTER subscriptions: $5.00 per year.

STONE CUTTER advertising rates: full page, $40.00; half page, $20.00; quarter page, $ 10.00.

STONE SETTING WORKSHOP

By popular demand Roy Greene will conduct a stone setting workshop during January, 1983. Now you can learn from an expert how to set your faceted stones and cabochons properly.

Three weekly sessions (more if needed) willbe held on Saturdays, January 8, 15 and 22. Classes will begin promptly at 2:30 PM. Fee for the three sessions will be $5.00.

Participants will learn to set round, oval, marquise and emerald shaped faceted stones and cabochons in prong and bezel settings.

You will need:

YOUR OWN TOOLS (pliers, files etc)

THE STONES YOU WISH TO SET and

THE SETTINGS (rings, pendants, earrings) YOU WISH TO USE.

Settings, stones and tools, if you don't have your own, are available at GEMCRAFTERS. Settings to fit the stones you plan to use should be sized and semi-polished.

If you have questions, drop by GEMCRAFTERS and talk to Roy.

CABOCHON CUTTING WORKSHOP

Merrill Snyder has agreed to conduct a workshop in cutting cabochons. This will follow the stone setting workshop. Plans are not yet complete. Come to the November meeting and learn more.

We have learned that Merrill also is a master cutter of spheres! Also that his sphere cutting machine is portable! Is a sphere a cabochon?

FACETING WORKSHOP

Considerable interest has been expressed in a faceting workshop, beginning and/or advanced. We are now seeking someone who is willing to conduct the faceting workshop. If you are willing to do this job in the Spring and share your abilities with other members, please contact Tom Ricks.

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MEET ME IN ST. PETE, Pete. Hope some of our members can attend the SHOW and CONVENTION of the SOUTHEAST FEDERATION in St. Petersburg, FL, NOV. 11 - 13.

Hosted by Pinellas Geological Society.

Skyway Inn, 3600 34th St. South.

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Advantages of Crown Apex Facets

by

PAUL C. SMITH
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Indianapolis, IN 46278

A few facet designs have appeared from time to time in which the conventional zero-degree table is replaced by several crown "apex" facets cut at low angles - say, 5 to 10 or 12 degrees. Back in 1977 such a design was published in a magazine and its author, in Australia, remarked that stones cut with apex facets were winning considerable acclaim in shows in that country. I have incorporated this feature in many of my own designs and feel that its advantages warrant greater use than it presently enjoys.

Before listing the advantages of apex facets one-by-one, we need to consider some of the qualities that are desirable in a faceted stone, then we can better judge whether apex facets are superior to zero-degree tables in each respect. Some of the qualities listed are subject to debate - that is, one person's idea of beauty or desirability may not agree with another's. As the poet has said, "Beauty is in the eye of the beholder."

1. The gem should have maximum brilliance.
2. It should sparkle or scintillate with slight movement of the gem, light source or viewer's eye position.
3. There should be no fisheye or areas that do not return light at some position or another.
4. Contrast between light and dark areas of the light pattern should be great.
5. Dispersive qualities of the gem material should be enhanced as much as possible.
6. Dichroic or trichroic material should display the best color.

Items 1 and 5 are generally agreed to be mutually exclusive - that is, greatest brilliance is obtained at the expense of high dispersion, and vice versa. Item 6 is mostly a function of proper orientation of the rough to start with, although the facet design may have some effect.

IDEAL VIEWING CONDITIONS. The facet designer needs to consider how the finished gemstone will be viewed. In a well-lighted jewelry store notice that many spotlights are used, evenly spaced in the ceiling, so that no matter where the customer stands or turns, the merchandise is sure to sparkle. It would be next to impossible to calculate all the light paths in a faceted gem under these conditions - the practical approach is to calculate for good performance under a few lights or just one light source and assume that a good design would display even better under a multiple source.

In the home, a gem is often viewed under a single light. Ideally, from the viewpoint of both designer and viewer, the path from light source to gem would coincide with the line of sight from the viewer to the gem but this is not possible because the viewer's head would shade the gem. Therefore the gem is usually held slightly in front of the viewer and the light is overhead and either in front, at one side or behind the viewer. A common viewing situation is shown in Fig. 1.

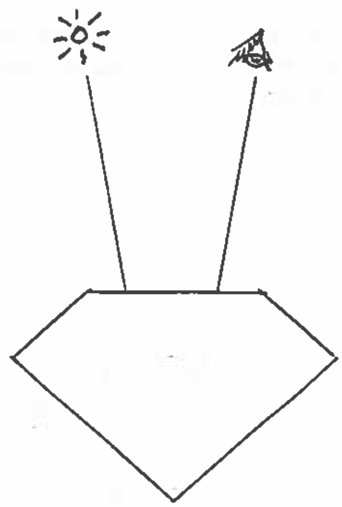

Fig. 1.

Obviously, the distances from gem to eye and light source are not to scale, but are greatly reduced to get everything on the page. The paths from source to gem and from gem to viewer are not parallel but at an angle that can vary according to relative positions of light, gem and viewer. Most viewers will automatically tip the gem to get the best display for the existing conditions.

LIGHT PATHS OUTSIDE AND INSIDE A GEM. For a faceted gem to appear most brilliant, all areas of the crown should return light to the viewer's eye, not necessarily at the same time, but the gem should not have to be tipped greatly to bring all areas into play. Three of the most common light paths are shown in Fig. 2.

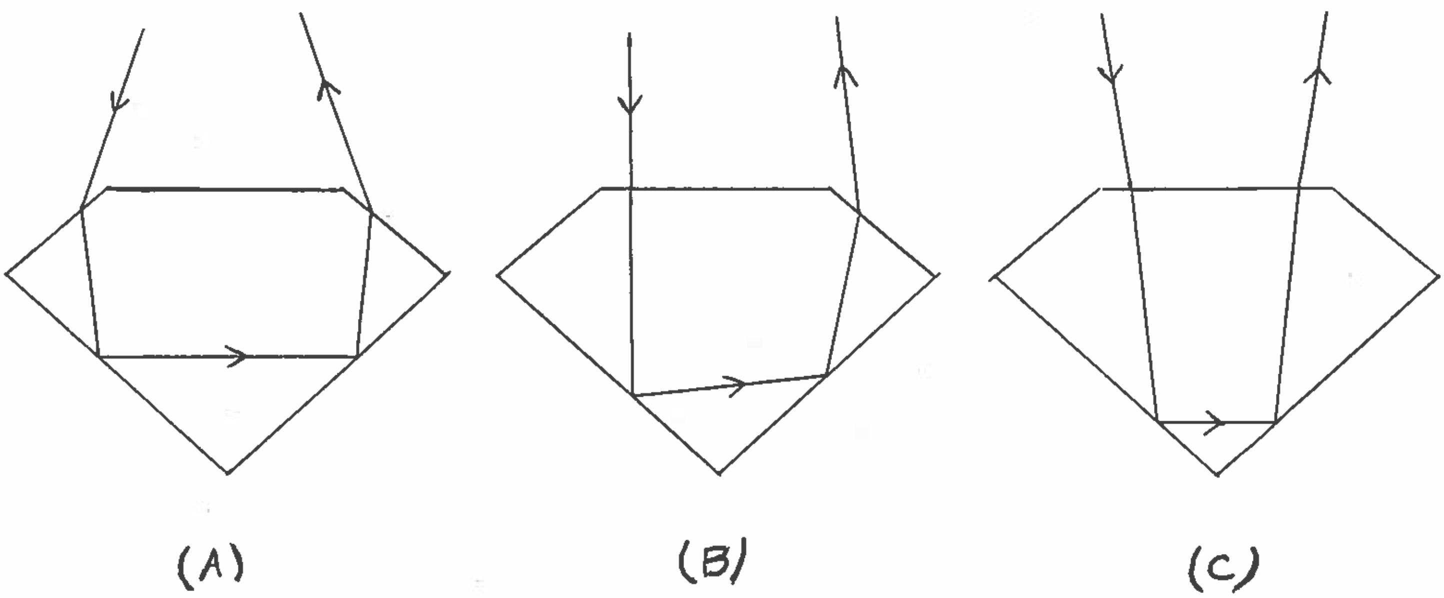

Fig. 2.
All diagrams are standard profile views with right- and left-hand facets indexed 180 degrees apart.

At Fig. 2A light enters one crown main and is reflected twice by the pavilion facets, leaving the opposite crown main facet. Under these conditions, the right-hand main will appear bright. The same path can serve for light entering the right-hand main and leaving the left, but light source and viewer must exchange positions.

At Fig. 2B light enters the left half of the table and leaves at the right crown main. This can also be reversed with light entering the right half of the table and leaving the left crown main.

At Fig. 2C light enters one half of the table and leaves at the other half. This, too, is reversible.

Other paths are possible, some with three or more internal reflections before leaving the gem, but they are less common and less likely to be useful.

We see from Fig. 2. that all areas of the crown of a faceted gem can return light to the viewer, but the light source is positioned differently in each example, and likewise the viewer's eye position is different. Is it possible to get conditions so that all areas return light from a single light source to a single eye position? Then the gem would appear bright all over, without the need for tilting or shifting. Well, while it may not be possible to attain perfection in that respect, the situation as shown in Fig. 2 can be greatly improved with the proper choice of angles.

Consider Fig. 3, showing a quartz gem with pavilion mains cut at 43.5 degrees. Light rays enter the left side of the table facet at such an angle that they are reflected across the pavilion parallel to the table plane (or girdle plane). The interior rays are 3 degrees from vertical and the exterior rays are 4.6 degrees from vertical, making the exterior angle between rays 9.2 degrees (1.54 times sine 3° = sine 4.6°. Most of the right half of the table would appear bright to a viewer's eye position at E.

Quartz

$n = 1.54$
$CA = 40.5^{\circ}$
$P = 43.5^{\circ}$

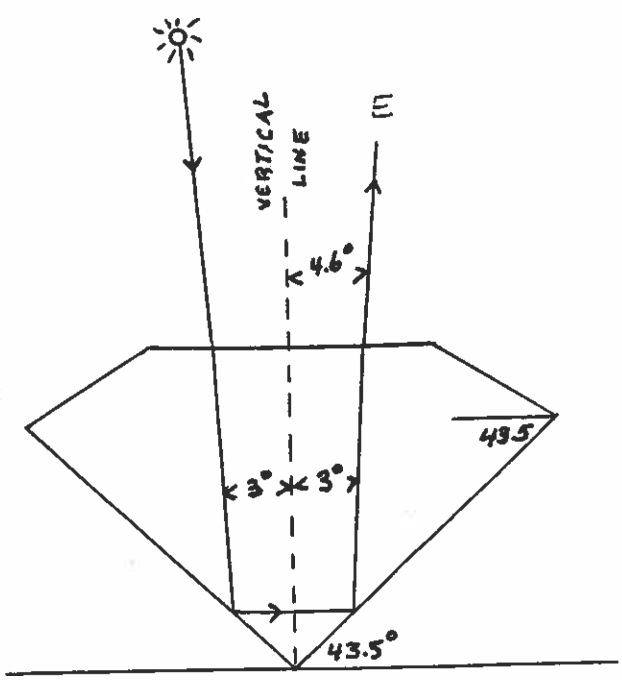

Fig. 3.

Now, assume that the positions of viewer, gem and light source are unchanged and the viewer's gaze shifts to the left half of the table as in Fig. 4A. We can safely say that the angle of viewing has not changed since the distance from eye to gem is normally great compared to the diameter of the gem. The line of sight must shift only an imperceptible amount to view any point on the crown. Inside the gem the path of the sight line is as shown, approaching the right crown main at 9 degrees from vertical. If the crown main is cut at 31.5 degrees, the path as it leaves the gem is bent to the left of vertical 4.6 degrees, and the light source is visible to the viewer. (It appears in Fig. 4A that light source and viewer's eye have exchanged positions, but this is the result of showing the ray paths shorter than they really are. Fig. 4B, although still limited in space, gives a better picture of the ray paths. The paths cross a short distance above the gem, so that the eye and light source are still at their original positions.)

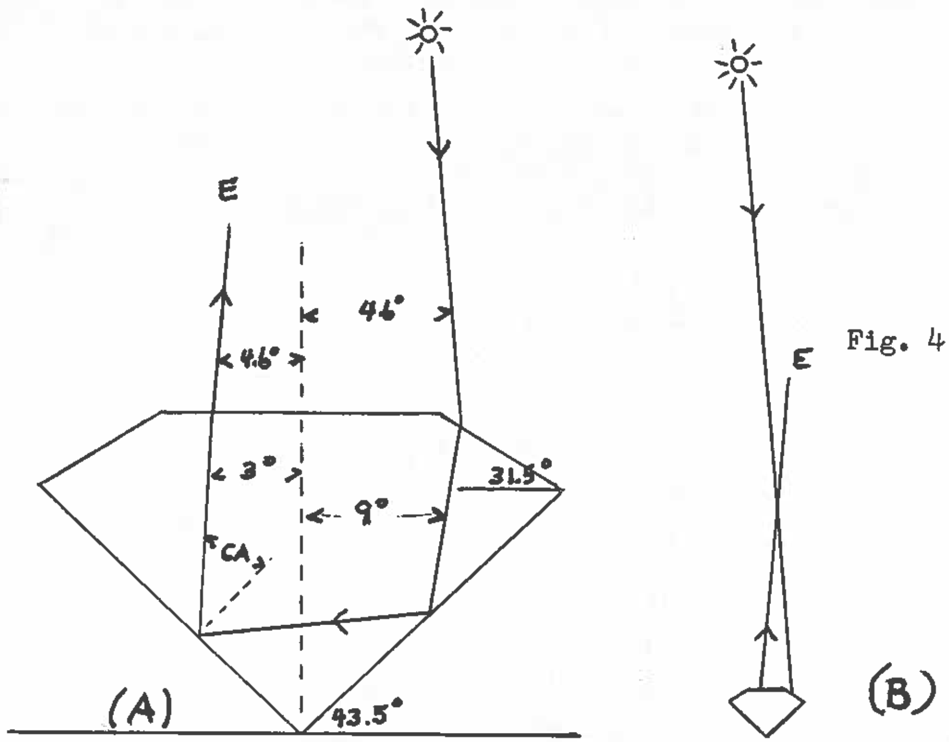

Fig. 4

If the sight line is shifted to the left crown main, we get a path that is a mirror image of Fig. 4A, appearing as in Fig. 5. The light source is again visible.

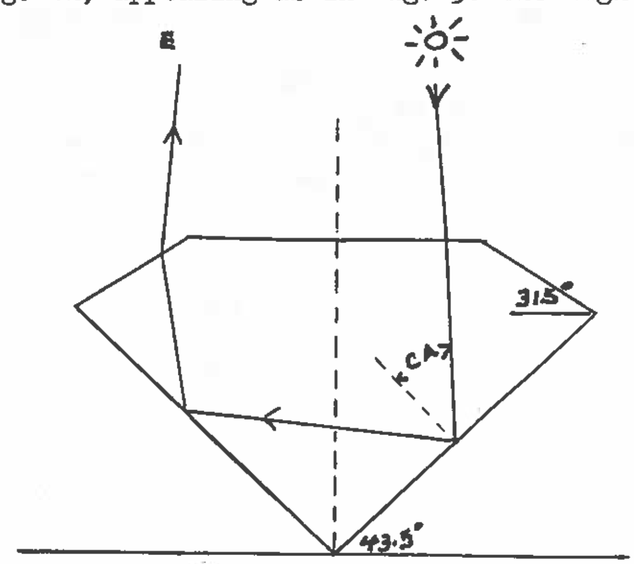

Fig. 5

So far we have achieved three-fourths of our objective. What about the right crown main? Unfortunately, if we look into it at the same angle as the others, the ray path will fall inside the critical angle on the left pavilion facet and be lost there. For this facet to appear bright would require some tipping of the gem and another light source. (Crown break facets can also contribute to the light pattern).

Crown and pavilion angles can be calculated for gem material of any refractive index, but the system as shown is still far from ideal. Notice in Figures 4 and 5 that the ray path is just at the dividing line between reflection and transmission at one pavilion facet. In Fig. 4A, if the gem is tipped ever so little away from the viewer, the light ray will fall inside the critical angle and be lost out the left-hand pavilion facet. Also, the system requires the pavilion main angle to be not less than (CA+90)/3, which gives pavilion angles slightly greater than usually recommended in published literature, especially for low refractive indexes. Above refractive indexes of about 1.63, the crown main angles required will not permit the ray path of Fig. 2A to function.

HOW APEX FACETS HELP. The limitations mentioned in the preceding paragraph can be reduced or eliminated by the use of apex facets. Figure 6 is used as a basis for some nomenclature and simple equations to follow. Again, the drawing represents a quartz gem with pavilion angle = 43.5 degrees.

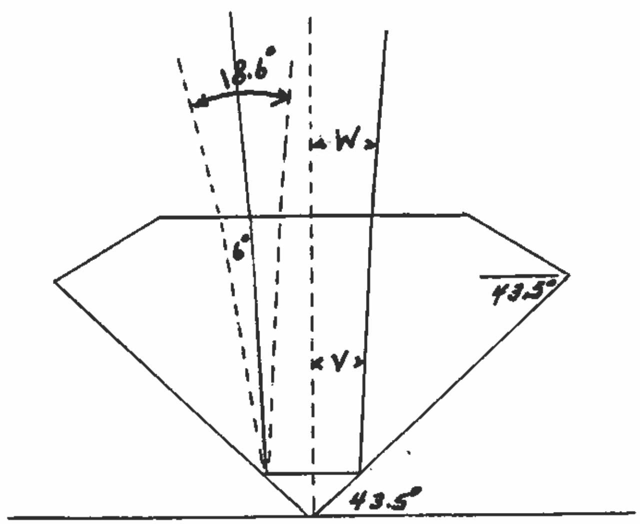

Fig. 6

A ray enters one side of the crown, strikes a pavilion facet, crosses the pavilion horizontally and reflects upward to leave the opposite crown facet. The angle the ray makes in its path up or down with reference to the vertical axis of the gem I call "V". In this special case the ray angle is the same on both sides of the axis so the total angle between the two sides of the ray path is 2V. If the ray crosses the pavilion other than horizontally V will be less on one side and greater on the other, but their sum will always be the same for any given value of P.

$$V = 90 - 2P \qquad (1)$$
$$V = 3$$

Outside the gem the ray path has a different angle with the vertical axis because of refraction. Call that angle "W". The value of W is easily obtained by the equation: Sine W = Sine V times refractive index, n.

$$W = 4.6^{\circ}$$

The viewing angle between light source, gem and viewer's eye (see Fig. 1) is 2W -- in this case 9.2°.

The angular range of rays that can be reflected from opposite pavilion facets is shown by the dashed lines on the left-hand facet. This range for any given value of P and critical angle CA is found by the equation:

$$\text{Angular range} = 2(90 - CA - P) \qquad (2)$$

The range in this example is $2(90 - 40.5 - 43.5) = 12^\circ$. The greater the range is, the greater the possibility of obtaining a brilliant gem. Equation (2) shows that lower values of CA and P result in a higher range. This indicates the value of using gem materials of high refractive indexes (high index = low critical angle). However, once you have chosen a specific material, you can increase the range only by decreasing P. But decreasing the value of P increases the chance of a fisheye, so in practice a compromise must be made.

In the example of Fig. 6, the interior range of 12 degrees results in an exterior range of18.6 degrees for rays that can be received by the table and reflected by the pavilion facets. Fig. 7 shows the pavilion angle reduced 1.5 degrees to 42 degrees and apex facets added. Light source, gem and viewer's position are not changed, so that W is still 4.6 degrees. This requires apex facets cut at 8.6 degrees. The change in pavilion angle has added 3 degrees to the internal angular range and the external range is now 23.2 degrees. This may not seem like much improvement, but with low-index materials we need all the help we can get. Besides, there are other advantages to apex facets which will be discussed.

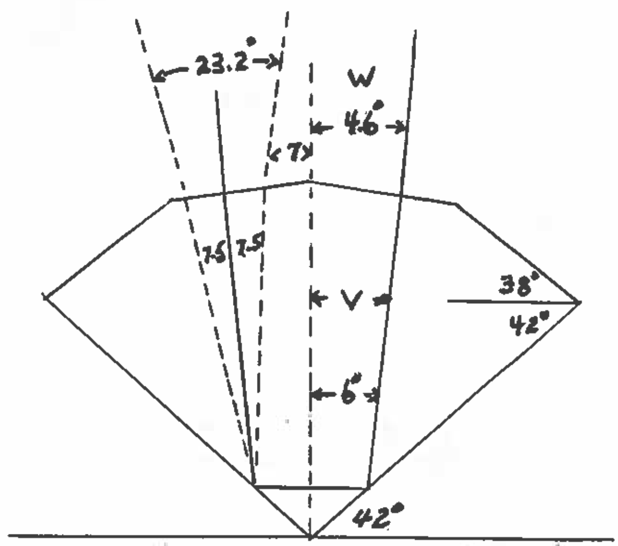

Fig. 7

Notice how P, V, W and the angle of the apex facets are all tied together: first you choose a value for P and this automatically determines V, according to equation (1). Next, the choice of apex angle relates V to W in the following manner. If apex angle and V are equal then there is no refraction as the ray passes from gem to air or vice versa. W then equals V. If apex angle is greater than V, refraction makes W less than V; if apex angle is less than V, refraction makes W greater than V. Finally, the value of W is used to calculate the crown main angle, C, so that the viewing condition shown in Fig. 4A is satisfied.

A number of choices for the apex angle are open depending on the desired value of W. The author has not made a conclusive study of this aspect, but in practice values of W from 5 to 10 degrees seem to perform satisfactorily. This allows considerable control over the crown main angle, and that is important if the ray path of Fig. 2A is to function. More on that later.

To summarize: With apex facets, the ray paths of Figures 3, 4, and 5 are maintained and the minimum value of P is not limited to (CA + 90)/3, as in Fig. 6. Reducing P provides a greater range of rays that can be received and reflected. Choice of P determines V; V, coupled with choice of apex facet angle, determines W and C. These two choices working together give a great number of combinations that can maintain the three ray paths.

SHOULD CROWN MAINS BE CUT ABOVE OR BELOW THE CRITICAL ANGLE??

There seem to be two schools of thought on this subject - one says above; the other says below. Perhaps it depends on the value of the pavilion main angle. Refer to Fig. 8, which shows a quartz pavilion cut at 42 degrees. The crown mains, C, are cut at the critical angle, 40.5 degrees.

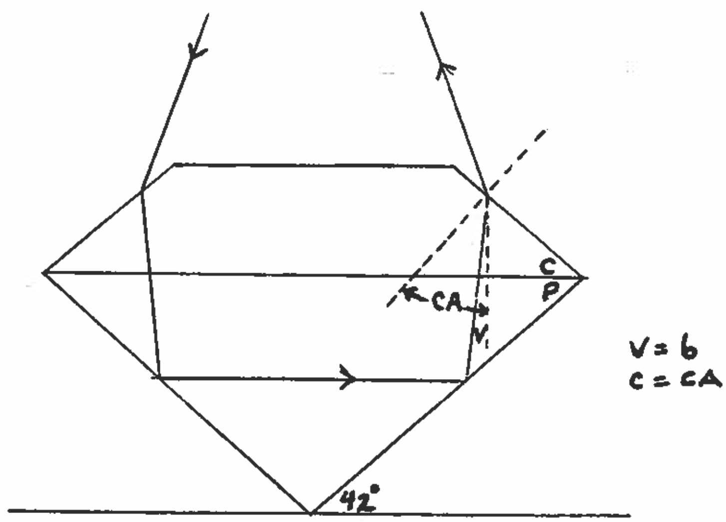

Fig. 8

Under these conditions a ray can enter one crown facet and leave the other one, as shown. For these angles, V equals 6 degrees and the ray falls within the critical by that amount. Therefore, C can be increased that much before the ray falls outside the critical angle and is totally reflected inside the gem. So we see that the maximum crown angle (Max C) that allows the ray path of Fig. 2A to function is CA + V or, substituting the expression for V, Equation (1), we get:

$$\text{Max } C = CA + 90 - 2P \qquad (3)$$

Substituting the values for quartz, CA = 40.5 degrees and P = 42 degrees, we get Max C = 46.5 degrees. This is well above the angles usually recommended for quartz crown mains. Equation (3) shows that for the values of P less than 45 degrees you can cut the crown mains of any material above its critical angle (by amount V) and still keep the ray path of Fig 2A active. A point to consider is that crown break facets are always cut at higher angles than the mains, so it might be well to cut the mains at less than Max C to give the break facets a chance to function.

OTHER BENEFITS OF APEX FACETS -

I suppose every faceter has had trouble at one time or another polishing the large area of a zero-degree table. Apex facets break that area up into several smaller areas easier to polish.

Rough with cleavage problems, such as topaz, can be dopped directly to the cleaveage plane.

Surface reflections from a large table area often reduce or obscure completely the pattern contrast beneath the table. We have all seen examples of this in otherwise very fine illustrations in gem books and magazines. Apex facets reduce this effect.

With some types of facet designs the pattern seen through the table does not scintillate as the gem is tipped; it merely seems to shift laterally. Apex facets create scintillation in this area.

Finally, the profile of a gem with apex facets is more pleasing to the author than the straight line of a flat, 55% table. (Purely a matter of taste - your taste may be different.)

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